INTEGRATED RISK

Introduction

The Commission, in staff requirements memorandum (SRM) of June 26, 2003, requested that the staff provide further details on options for, and the associated impacts of, requiring that modular reactor designs account for the integrated risk (i.e., cumulative effect on risk to the population around a site) posed by the use of multiple small reactors to equal the power output of one large reactor. These reactor modules generally would be located in close proximity to one another on a single site. The use of modular reactor designs is considered by some in the industry to be an attractive alternative to large single units because of the potential inherent safety characteristics of some modular designs (e.g., passive decay heat removal) and potential economic advantages (e.g., increased use of factory fabrication and stepwise construction and operation to bring modules on line as needed). Accordingly, the use of modular designs could result in a large number of reactors located on a single site.

Background

Traditionally, it has been the staff's practice in making risk-informed decisions to consider risk on a per plant basis. This has been considered reasonable because of the limited number of plants on a site (maximum three) and because of the low risk generally posed by currently operating plants as indicated by staff and industry studies (e.g., NUREG-1150, "Individual Plant Examination Program"). However, it is recognized that the population around a site is exposed to the hazard of everything that is on that site. In promulgating the Safety Goal Policy in 1986, the terms "plant" and "site" were both used. Whether this was intended to address integrated risk or not is not clear, but is a consideration with respect to how to treat integrated risk. Nevertheless, with the potential for modular reactors in the future, it is appropriate to consider when and how (if at all) integrated risk should be addressed, since the number of reactors on a site could be significantly more than three.

In SECY-03-0047, "Policy Issues Related to Licensing Non-Light Water Reactor Designs," the staff recommended and the Commission approved (in a June 26, 2003 SRM) a process for licensing new plants that parallels that used in the design certification of the evolutionary and advanced Light Water Reactors (LWRs). This process is based upon the Commission's expectation that new reactor designs will be safer than currently operating LWRs and will comply with the Commission's Safety Goal Policy, and that the need for additional features to address uncertainties will be determined on a plant-specific basis, with Commission approval. Accordingly, the addition of a single new reactor to a site with currently operating reactors would not add substantially to the overall risk. However, in making the recommendation in SECY-03-0047, the staff recognized that the addition of a modular reactor design to a site could add a large number of reactors to the site and thus recommended they be treated differently in that their integrated risk be considered. The Commission, in its June 26, 2003, SRM, requested that the staff provide further details and options for this recommendation.

In response to the Commission's June 26, 2003, SRM, the staff has reviewed previous dockets for sites where multiple reactors were approved to see if and how the issue of integrated risk was addressed. NRC has issued operating licenses to sites for three reactors. (e.g., Palo Verde) and granted construction permits for four reactors at several sites (Shearon Harris, North Anna, Surry, Hartsville, and Vogtle). These construction permits were granted on the basis of safety evaluations and environmental impact statements. However, these safety evaluations and environmental impact statements did not consider the risk (individually or integrated) from accidents and, therefore, are not considered potential precedents. In all cases, the integrated affect of plant impacts on the environment from normal operation (e.g., thermal discharges, radiological releases from routine operation) were considered, but not the integrated risk from reactor accidents.

Discussion

Discussed below are three initial approaches for considering integrated risk in licensing decisions for modular reactors. The advantages, disadvantages, and impacts of each approach are discussed. In addressing integrated risk, risk associated with both accident prevention (e.g., core damage frequency[1]) and accident mitigation (e.g., large early release frequency[1]) are considered. A key factor is megawatt thermal power size of the reactor (i.e., reactor power level). Specifically, risk measures for accident prevention are considered to be independent of reactor power level (i.e., it is just as important to prevent core damage accidents in small reactors as it is in large reactors), whereas risk measures for accident mitigation may be dependent on reactor power level (i.e., the source term will vary). In this assessment, base case risk is that associated with a large reactor design (i.e., ~1300 Mwe).

No consideration of integrated risk

This approach would essentially maintain the status quo in that the risk information is developed and evaluated on a per reactor basis not a per site basis, in regulatory decisions related to reactors (licensing, license amendments, or oversight). This approach has been judged acceptable for currently operating plants given that current sites in the U.S. have a relatively small number of reactors (up to three) and many currently operating reactors achieve a level of safety comparable to that expressed in the Commission's Safety Goal Policy, thus ensuring their integrated risk is small. In the future, new reactor designs are expected to have significantly less risk (at least an order of magnitude lower based upon insights from reviews completed to date) than current operating reactors. If this expectation is realized, neither modular designs or large designs would individually contribute significant additional risk to public health and safety. This approach does not distinguish between large and small reactors and is reasonable if the number of modular reactors added to a site were limited, since it serves to limit integrated risk. Also, it can be argued that uncertainties in risk assessments could be larger than the cumulative risk obtained by combining the risk from all reactor modules. However, since uncertainties are to be considered in risk-informed decisions, this should not be a reason to ignore cumulative effects.

[1]It should be noted that as part of work on a risk-informed process for new plant licensing, the staff is currently developing technology-neutral risk metrics for accident prevention and mitigation, recognizing that core damage frequency and large early release frequency may not be appropriate for non-LWRs. In this regard, the use of Level 3 risk assessment is also being evaluated.

This approach is consistent with an interpretation of the Commission's Safety Goal Policy that risk should be evaluated on an individual reactor basis and also have minimal impact on current practices being used in risk-informing reactor regulatory requirements and activities, which assess risk on an individual reactor basis.

Consideration of integrated frequency

This approach would require only consideration of integrated frequency in assessing all risk measures (prevention and mitigation) for new reactor licensing decisions, independent of reactor module power level. In effect, it requires that the frequency associated with the risk criteria applied to large reactor designs be reduced for modular designs in proportion to the number of reactor modules needed to equal the output of a large reactor. This approach ensures that the integrated frequency associated with accident prevention (e.g., core damage frequency) from modular reactors is no greater than the frequency associated with accident prevention for a large reactor on a per MW basis. The effect of reactor power level on risk criteria associated with accident mitigation, however, is not taken into account. This assumption will likely result in a de facto more stringent goal than intended by the Commission's Safety Goal Policy, which was derived on a per unit basis not a per site basis.

This approach broadens the frequency range of initiating events and event sequences which will have to be considered in a modular reactor risk assessment (as compared to a risk assessment for a large reactor). The need to consider a broader frequency range will occur since lower frequency events and event sequences will need to be considered to ensure that the lower frequency accident prevention and mitigation measures needed for each reactor module are adequately assessed. This approach is consistent with an interpretation of the Commission's Safety Goal Policy that risk should be evaluated on a per site basis.
This approach also requires some changes in current practices for risk-informed activities when applied to modular reactors to account for integrated risk.

Consideration of integrated risk (reactor power level and frequency)

This approach would recognize that accident prevention is important, regardless of reactor power level, whereas in many cases accident mitigation is related to reactor power level (i.e., the lower the reactor power, the fewer fission products are available for release to the environment and thus the more difficult it is to have a large release). Accordingly, the integrated frequency associated with accident prevention risk criteria will need to be taken into account for modular reactor designs (similar to the second approach). However, the integrated risk associated with accident mitigation risk criteria could take into consideration reactor module size. This approach recognizes the dependence of risk metrics associated with accident mitigation on reactor power level and will result in the integrated risk from multiple reactor modules being at least as low as the risk from an equivalent large reactor design. Therefore, it will address integrated risk most realistically.

Like the second approach, this approach requires that in assessing accident prevention, the risk assessment consider events and event sequences of low enough frequency to ensure that accident prevention measures can be adequately assessed. This approach also requires that whatever accident mitigation risk measures are applied to modular reactors, they include consideration of reactor power and that some practices for risk-informed activities will need to be modified to address integrated risk for modular reactors. In addition, this approach

represents an interpretation of the Commission's Safety Goal Policy that risk metrics associated with accident prevention and mitigation be assessed on a per site basis.

Future Plans

The staff plans to continue to evaluate the above approaches and the views received from the ACRS. Further stakeholder input will also be solicited and considered in the evaluation. Options and a recommendation on the issue of integrated risk for small, modular reactors will be coordinated with and included in the paper planned for late 2004 on the technology-neutral framework for new plant licensing.